Design and Implementation of Collaborative Cloud-Edge System Using Raspberry Pi for Video Surveillance System with AIoT to Analyse Effective Performance Parameters of Network.

Dr. Trupti Kaushiram Wable[1]

[1]*Assistant Professor, Department of Electronics & Telecommunication, SVIT, Nashik, India*

E-mail: trupti.wable@pravara.in

Abstract - ***The video surveillance can avoid many crimes as well as it will help to reduce crime rate in society as well we can save many lives. But currently implemented IoT system having various limitations like insufficient storage capacity and inadequate processing of information. Thus we can integrate traditional IoT system with Artificial Intelligence (AI) models to improve storage capacity & processing called as Artificial Intelligence of Things (AIoT). This system mainly focuses on performance parameter of video surveillance system the parameter consist of Response Latency Time, Network Bandwidth & Storage on server. In proposed system divided in two part, First part include Edge node implemented with Raspberry Pi as IoT system which having video input then it perform image processing & store output on edge node, second part include cloud node which is train with AI model as AI system to extract image and analyzed performance of system. So Cloud-Edge Collaborative system refers as Artificial Intelligence of Things (AIoT). In this research I conclude comparative study of traditional Cloud Computing System with Collaborative Cloud-Edge Computing system which shows that, the Response Latency Time improve by 5 times, Network Bandwidth improve by 10 times and storage capacity improve by 5 times of traditional Edge Computing System.***

Keywords: Cloud-Edge collaboration, Cloud Computing, Edge Computing, Artificial Intelligence, Internet of Things.

I. Introduction

AIoT (Artificial Intelligence of Things) is a cloud-edge collaborative system that enables video surveillance using Raspberry pi. AIoT uses distributed computing technology to process data from multiple sources at the edge, such as cameras, ultrasound rangefinders, and object recognition systems.[1] The data is then sent to cloud for further processing and storage. At the cloud, AI-driven analytics is applied for insights. The insights are used to take informed decisions for better video surveillance. Raspberry pi is used as the edge device in the AIoT system. It is equipped with sensors such as camera, ultrasonic range sensor and object recognition system, which collect data from the environment. The collected data is then sent to the cloud for further processing and analytics.[3] At the cloud, the data is analysed with the help of AI-driven analytics. It is used to take informed decisions for better video surveillance. For example, the data obtained from the sensor can be used to identify intruders, detect fires, and track people in the surveillance area. The insights from the data can be used by the security personnel to take appropriate action to secure the environment.[4] The AIoT system is also used to improve safety and security in public places such as airports, railway stations and shopping malls. It enables the security personnel to monitor the environment and take appropriate action in unsafe situations. In conclusion, AIoT as a cloud-edge collaborative system for video surveillance using Raspberry pi can be used to improve safety and security in public places. The insights obtained from the sensor data can be used to take informed decisions to secure the environment.[6]

The Raspberry Pi is also the perfect candidate for performing other important security-centric tasks such as anti-tampering and motion detection. Additionally, the use of AI-based algorithms and techniques such as machine learning, and deep learning can help reduce false positives and further enhance the security of the system. This will ensure that the data stream is safe and can be used for analytics and other applications without compromising security. Furthermore, the Raspberry Pi will enable a distributed architecture that can scale to meet the demands of a growing customer base. This scalability and flexibility will allow for a more affordable and efficient solution compared to other solutions. By combining the power of the cloud and the intelligence of the edge in a unified lightweight system, CECVS using AIoT is a powerful new concept for modern surveillance.[4]

Need of Cloud-Edge collaboration

The need for cloud-edge collaboration arises from the specific requirements and challenges of modern computing environments, particularly in contexts such as Internet of Things (IoT), Artificial Intelligence (AI), and real-time data processing. Here are some key reasons why cloud-edge collaboration is necessary:

1. *Reduced Latency and Real-Time Processing*: In many applications, there is a need for real-time or near real-time data processing and analysis. By combining the computational power of the cloud with the agility of edge devices, cloud-edge collaboration enables faster data processing and reduces latency.[2]

2. *Bandwidth Optimization*: In scenarios where large volumes of data are generated at the edge, transmitting all the data to the cloud can be impractical due to limited bandwidth or high costs. By collaborating with the cloud, edge devices can process and filter data locally, transmitting only relevant information. This helps optimize bandwidth and reduces network congestion.[2]

3. *Enhanced Security and Privacy*: Cloud-edge collaboration enables sensitive data to be processed and stored locally at the edge, reducing the risk of data breaches during transmission to the cloud. This is particularly important in industries such as healthcare, finance, and government, where data security and privacy are major concerns.[3]

4. *Scalability and Resource Efficiency*: Cloud-edge collaboration allows for a more distributed and scalable computing infrastructure. Edge devices can offload processing tasks to the cloud, leveraging its virtually unlimited resources when required. This dynamic resource allocation enhances scalability, flexibility, and resource efficiency.[2]

II. Implementation of AIoT as Cloud-Edge Collaborative system using Raspberry pi:

AIoT (Artificial Intelligence of Things) is a relatively new concept that combines the principles of artificial intelligence and the Internet of Things (IoT). Instead of relying solely on edge computing solutions, it establishes a cloud-edge collaborative system to solve complex problems in an automated, smarter, more efficient manner. One of the most efficient ways to implement such a system is using a single-board computer, like the Raspberry Pi (Rpi). The Rpi provides a low-cost and highly extensible platform for developing AI and IoT applications. It can host multiple applications, from connected home technologies to robotics applications.[2] It also can provide a gateway for connecting to the cloud, allowing edge and cloud devices to communicate with each other. To set up a cloud-edge collaborative system, multiple Rpi can be connected together to form a mesh network. Each node in the network can act as an edge device, collecting and processing data, and communicating with the cloud. This data can be used to trigger certain events, like the activation of an alarm system when a security breach is detected. The Rpi can also act as a gateway for connecting IoT devices, such as sensors, cameras, and other peripherals. The data collected by these devices can be sent to the cloud, allowing AI to monitor and analyze the data in real-time.[1]

1. Hardware setup:

- Obtain a Raspberry Pi board (such as Raspberry Pi 4) and necessary accessories like power supply, SD card, and a camera module.
- Connect the camera module to the Raspberry Pi's camera interface.
- Set up the Raspberry Pi by installing the operating system (e.g., Raspberry Pi OS) on the SD card and booting up the board.

2. Software setup:

- Install necessary dependencies, libraries, and frameworks. This may include OpenCV (for image/video processing) and TensorFlow (for object detection).
- Configure the operating system to enable the camera module and configure network settings (to connect to the network for remote access).

3. Camera calibration:

- Calibrate the camera module to correct any distortion and obtain the intrinsic parameters. This can be done using calibration patterns and OpenCV's camera calibration functions.

4. Real-time video/image processing:

- Implement real-time video or image processing algorithms on the Raspberry Pi using the installed libraries and frameworks. This can include tasks such as detecting objects, tracking motion, or analyzing image data.

- Utilize the camera module to capture images or video streams in real-time.

5. Storage and transmission:

- Decide whether to store the captured images/videos locally on the Raspberry Pi or transmit them to a central server or cloud storage.
- If storing locally, implement mechanisms to manage storage space, such as deleting old recordings or compressing the files to save storage.
- If transmitting to a central server, integrate network protocols (e.g., FTP or MQTT) for secure and efficient transmission.

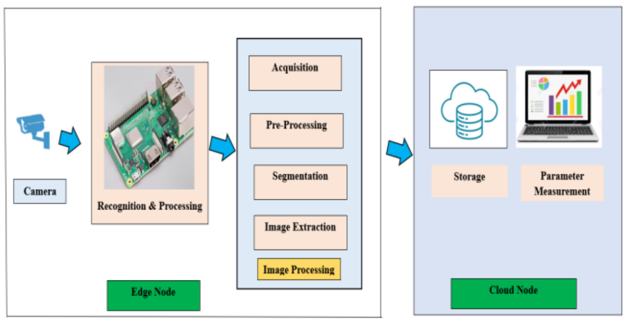
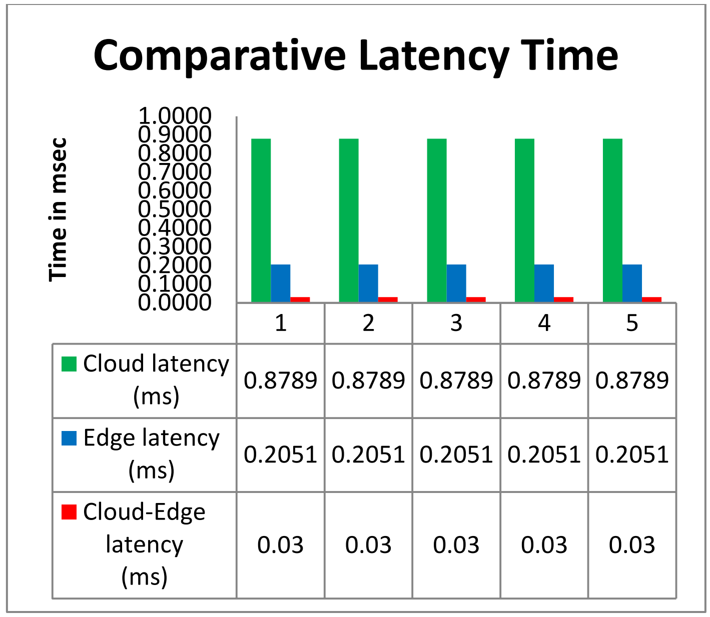


Figure 1- Proposed Cloud-Edge System

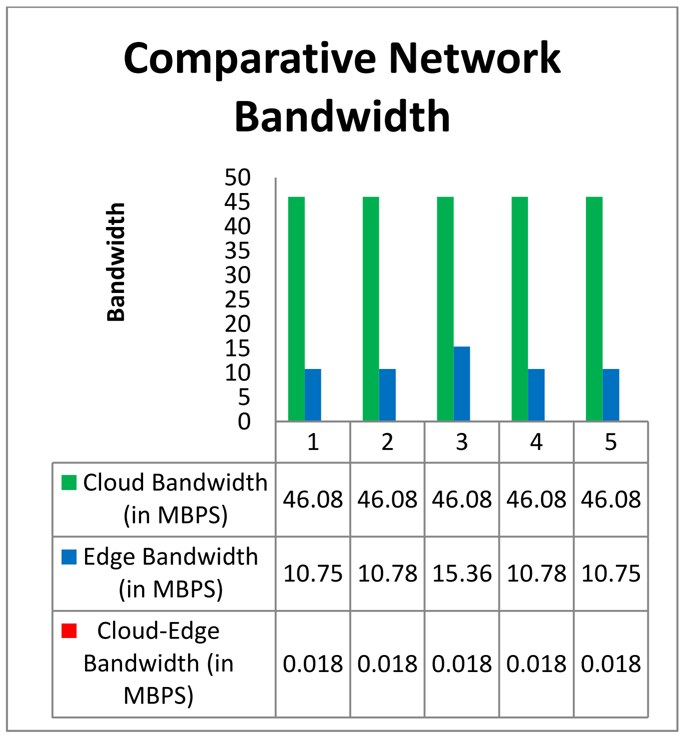
III. Result & Discussion

1. The hybrid system is collaboration of Edge & Cloud Computing node to get advantages of both Edge and Cloud system.
2. At Cloud end we capture image and perform detection & shape invariance and rotation invariance and finally colour matching.
3. After that at Edge end image processing perform on image and we extract features of image.
4. At hybrid end we combine result of both system to analyse bandwidth and latency of hybrid system.
5. The extracted image store at hybrid end so storage capacity reduced and we get moderate response for bandwidth and latency.



	1	2	3	4	5
Cloud latency (ms)	0.8789	0.8789	0.8789	0.8789	0.8789
Edge latency (ms)	0.2051	0.2051	0.2051	0.2051	0.2051
Cloud-Edge latency (ms)	0.03	0.03	0.03	0.03	0.03

Figure-2 Comparative Analysis for Cloud-Edge system for Latency Time



	1	2	3	4	5
Cloud Bandwidth (in MBPS)	46.08	46.08	46.08	46.08	46.08
Edge Bandwidth (in MBPS)	10.75	10.78	15.36	10.78	10.75
Cloud-Edge Bandwidth (in MBPS)	0.018	0.018	0.018	0.018	0.018

Figure-3 Comparative Analysis for Cloud-Edge system for Bandwidth

Discussion:

The compare results of Cloud, Edge and Hybrid systems it is clear that the performance of Collaborative Cloud-Edge system is better than traditional Cloud and Edge system. From results obtained Cloud system having average Network Bandwidth of 46.08 MBPS, Edge system having average Network Bandwidth of 10.46 MBPS and Hybrid system we get Network Bandwidth of 0.0180 MBPS which is quite less than Cloud and Edge system. Also the Response Latency time we required for Cloud system as 0.8789msec, for Edge system 0.0250 and for Collaborative Cloud-Edge system we get result as 0.0305msec thus Collaborative Cloud-Edge system having better Response Latency time than Cloud and Edge system. Overall the if we implement cloud system then it gives scalability and cost effective solution but at same time it required larger Network Bandwidth and Response Latency time. The Collaborative Cloud-Edge system gets better performance than cloud and Edge system.

IV. CONCLUSION

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